REMARKS

Claims 1-12 have been examined. Claims 1, 3, 8-10 and 12 have been rejected under 35 U.S.C. § 102(b), claims 2, 4, 6, 7 and 11 have been rejected under 35 U.S.C. § 103(a).

I. Preliminary Matters

As suggested by the Examiner on page 3 of the July 25, 2003 Advisory Action, Applicant has amended claim 1 to further define the structure. Also, the Examiner indicated that the claimed method (i.e. claim 8) does not clearly recite that the supply of ink is responsive to both the recited count referral and quantity detection. Therefore, Applicant has further amended claim 8 for clarification.

In addition, as stated in the Office Action Summary, the present Office Action is responsive to communications filed on September **4**, 2003 (i.e. the RCE). Therefore, it appears that the Examiner did not receive and consider the Preliminary Response, filed on September **12**, 2003, prior to issuing the present Office Action. Accordingly, the comments presented below are similar to the comments set forth in the September 12, 2003 Preliminary Response.

II. Rejection Under 35 U.S.C. § 102(b) to U.S. Patent No. 6,155,664 to Cook ("Cook").

Claims 1, 3, 8-10 and 12 have been rejected under 35 U.S.C. § 102(b) as being anticipated by Cook.

A. Claim 1

Applicant submits that claim 1 is patentable over the cited reference. For example, claim 1 recites an ink level detector configured to detect at least a low ink state in which quantity of ink

stored in a sub-tank is smaller than a predetermined value. Further, an ink consumption counter is configured to acquire the total quantity of ink ejected or discharged by the recording head. When the ink level detector detects the low ink state, and the value acquired by the ink consumption counter reaches a predetermined count value, ink is supplied to the sub-tank by the ink cartridge.

The Examiner maintains that Cook discloses the above features. In particular, in both the current Office Action and the July 25, 2003 Advisory Action, the Examiner maintains that Cook discloses that a simultaneous measurement of the ink level is obtained by a level sensor 30a, 30b and a counter 36, and that these values are compared to determine if the counter is working properly (Fig. 6; steps 158, 160). The Examiner further maintains that the refill of ink occurs only in the condition that both the sensor 30a, 30b and the counter 36 indicate a low ink level (Fig. 6; step 164, 178).

However, similar to Applicant's comments set forth in the September 12, 2003 Preliminary Response, Applicant submits that the may be Examiner misinterpreting the cited reference. For example, in Cook, the printer controller 36 compares the measured primary ink level value with a stored primary ink level value (step 160). If the ink level values do not match, the printer controller determines that either one or more primary ink level sensors 30a-30b have failed or an inaccurate primary ink level value was stored (col. 14, lines 22-59). The printer controller 36 then generates a system fault message indicating that user service is required (step 163). This comparison is performed for confirming whether the printer works properly, not for

determining whether a refill operation is required or not. In particular, no ink is supplied or refilled upon completion of this comparison, as required by the claims.

Further, the refill operation disclosed in Cook is performed based on only the primary drop count value, not both the primary drop count value and the output of the primary ink level sensors 30a-30b. For example, the ink level sensors 30a-30b are used only for detecting an ink "full" state, i.e. to indicate whether primary ink reservoir 4 has become full or not, during ink transfer from secondary reservoir 10 to primary reservoir 4 (col. 15, lines 53-62). In other words, the printer controller 36 refers to the values of ink level sensors 30a-30b, after a supply of ink has already begun. Therefore, ink level sensors 30a-30b are not used as a condition to commence the supply of ink in an ink refill operation.

Accordingly, Applicant asserts that Cook fails to disclose that, when the ink level detector detects the low ink state and the value acquired by the ink consumption counter reaches a predetermined count value, ink is supplied to the sub-tank by the ink cartridge, as recited in the claims.

B. Claim 3

Since claim 3 is dependent upon claim 1, Applicant submits that such claim is patentable at least by virtue of its dependency.

C. Claim 8

Since claim 8 recites a method utilizing features which are analogous to the features recited in claim 1, Applicant submits that claim 8 is patentable for at least similar reasons as set forth above.

D. Claims 9 and 10

Since claims 9 and 10 are dependent upon claim 8, Applicant submits that such claims are patentable at least by virtue of their dependency.

E. Claim 12

Since claim 12 has been canceled, without prejudice or disclaimer, Applicant submits that the rejection of such claim is now moot.

III. Rejection Under 35 U.S.C. § 103(a) over U.S. Patent No. 6,155,664 to Cook ("Cook") in view of EP 841 173 to Kobayashi et al ("Kobayashi").

Claims 2 and 7 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Cook in view of Kobayashi. However, since claims 2 and 7 depend on claim 1, and Kobayashi fails to cure the deficient teachings of Cook, Applicant submits that claims 2 and 7 are patentable at least by virtue of their dependency.

IV. Rejection Under 35 U.S.C. § 103(a) over U.S. Patent No. 6,155,664 to Cook ("Cook") in view of U.S. Patent No. 4,432,005 to Duffield et al ("Duffield").

Claim 4 has been rejected under 35 U.S.C. § 103(a) as being unpatentable over Cook in view of Duffield. However, since claim 4 depends on claim 1, and Duffield fails to cure the deficient teachings of Cook, Applicant submits that claim 1 is patentable at least by virtue of its dependency.

V. Rejection Under 35 U.S.C. § 103(a) over U.S. Patent No. 6,155,664 to Cook ("Cook") in view of U.S. Patent No. 4,466,284 to Dumery ("Dumery").

Claim 6 has been rejected under 35 U.S.C. § 103(a) as being unpatentable over Cook in view of Dumery. However, since claim 6 depends on claim 1, and Dumery fails to cure the deficient teachings of Cook, Applicant submits that claim 6 is patentable at least by virtue of its dependency.

VI. Rejection Under 35 U.S.C. § 103(a) over U.S. Patent No. 6,155,664 to Cook ("Cook") in view of EP 1 097 814 to Tamura et al ("Tamura").

Claims 6 and 11 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Cook in view of Tamura. However, since claims 6 and 11 depend, either directly or indirectly, on claim 1, and Tamura fails to cure the deficient teachings of Cook, Applicant submits that claims 6 and 11 are patentable at least by virtue of their dependency.

In addition, the publication date of Tamura (i.e. May 9, 2001) is after the filing date (i.e. December 21, 2000) of JP 2000-389223. Further, it appears that Tamura's priority documents were published after the filing date of the priority document of the present Application. Accordingly, Applicant's submit herewith a verified English translation of JP 2000-389223 to perfect Applicant's claim to foreign priority. Applicant submits that the priority document provides support, under 35 U.S.C.§ 112, first paragraph, for the rejected claims.

Accordingly, Applicant respectfully requests the Examiner to withdraw the rejection.

VII. Allowable Subject Matter

As stated above, the Examiner has indicated that claim 5 contains allowable subject matter. Accordingly, Applicant has rewritten claim 5 into independent form.

VII. Conclusion

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

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Date: January 30, 2004

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of Docket No: Q67848

Yoshiharu ARUGA, et al.

Serial No.: 10/024,643 Group Art Unit: 2853

Filed: May 24, 2001 Examiner: Blaise L. Mouttet

For: INK JET RECORDING APPARATUS, AND METHOD OF SUPPLYING INK TO BE SUB-TANK OF THE INK JET RECORDING APPARATUS

DECLARATION UNDER 37 CFR 1.55(a)
(Pursuant to 37 CFR 1.68)

Honorable Commissioner of Patents and Trademarks
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, TOSHIMASA SUZUKI, declare and state:

that I am a citizen of Japan, having an Office at P.O. Box 521, ARK Mori Building 13F, 12-32, Akasaka 1-chome, Minato-ku, Tokyo, 107 JAPAN;

that I well understand the Japanese and English languages;

that the attached English-language documents are full, true and faithful translations made by me of Japanese Application No. 2000-389223 filed on December 21, 2000 on which the rights of priority under the International Convention are all claimed for

the above-identified application.

I declare further that all statements made herein of my own knowledge are true that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful statements may jeopardize the validity of the Application or any patent issuing thereon.

Date: December 26, 2003

Toshimasa SUZUKI

PATENT OFFICE

Japanese Government

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: December 21, 2000

Application Number: 2000-389223

Applicant(s): SEIKO EPSON CORPORATION

November 26, 2001

Commissioner,
Patent Office: Kozo Oikawa

Issuance No. 2001-3102070

[Document Name] Patent Application

[Reference No.] J0081642

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[Addressee] Commissioner, Patent Office, Kozo Oikawa Esq.

[Intl. Patent Classification] B41J 2/175

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[Name or Appellation] Shigeru Kinoshita

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[Deposit Account Number] 063692

[Amount of Fee] 21000 yen

[List of Filed Documents]

[Filed Document Name]	Specification	1
[Filed Document Name]	Drawing	1
[Filed Document Name]	Abstract	1
[General Power of Attorney No.]	0000257	

[Request for Proof] Request

[Designation Of Document] Specification

[Title Of The Invention]

INK-JET RECORDING APPARATUS, AND METHOD FOR REPLENISHING INK IN SUB-TANK FOR THE INK-JET RECORDING APPARATUS

[Claims]

[Claim 1]

An ink-jet recording apparatus comprising:

a recording head, which, being mounted on a carriage, is reciprocally moved across the width of a recording sheet;

a sub-tank, which, being mounted on said carriage adjacent to said recording head, is supplied with ink from an ink cartridge and supplies said ink to said recording head;

wherein said sub-tank includes

ink level detection means, for at the least detecting a low ink state, in which the amount of ink retained in said sub-tank is smaller than a predetermined value, and a full ink state, in which the amount of ink retained in said sub-tank reaches said predetermined value, and

a consumed ink quantity counter, for acquiring, as a total, the quantity of ink ejected or discharged by said recording head, and

wherein, when a low ink state has been detected by said ink level detection means and said value acquired by said consumed ink quantity counter has reached a predetermined count level, ink is supplied to said sub-tank by said ink cartridge.

[Claim 2]

An ink-jet recording apparatus according to claim 1, wherein said predetermined ink amount total held by said consumed ink quantity counter is set equal to or smaller than "an effective ink amount in said sub-tank - the amount of ink to be ejected by said recording head during one cleaning operation".

[Claim 3]

An ink-jet recording apparatus according to claim 1 or 2, wherein an ink supply valve is located along an ink supply path extending from said ink cartridge to said sub-tank, and when said ink supply valve is opened, ink is supplied to said sub-tank.

[Claim 4]

An ink-jet recording apparatus according to one of claims 1 to 3, wherein an ink pack, composed of a flexible material in which ink is enclosed, is stored in said ink cartridge, the outer block member of which is airtight; and wherein air under pressure is introduced by a pneumatic pump into a space that is defined by said ink pack and said outer block member of said ink cartridge, and under said air pressure, ink from said ink cartridge is supplied to said sub-tank.

[Claim 5]

An ink-jet recording apparatus according to claim 4, wherein said ink quantity detection means detect an overflow state in which the amount of ink retained is greater than in said full ink state. When an overflow state is detected, an operation is initiated for opening said ink supply valve and for releasing, to the atmosphere, said air pressurized

by said pneumatic pump.

[Claim 6]

An ink-jet recording apparatus according to claim 1, wherein said ink quantity detection means for detecting the quantity of ink retained in said sub-tank includes:

a float member, which floats on ink that is supplied to said sub-tank; and

magnetoelectric conversion means, for utilizing the magnetic force exerted by a permanent magnet, mounted on said float member, to generate, in consonance with the afloat positioning of said float member relative to said magnetoelectric conversion means, an electric output.

[Claim 7]

An ink-jet recording apparatus according to claim 1 or 2, wherein said ink quantity counter obtains the amount of ink consumed by performing a multiplication process using a coefficient based on the number of ink droplets ejected by said recording head, or by performing a multiplication process, using said coefficient, each time a cleaning operation is performed to attract and discharge ink from said recording head.

[Claim 8]

An ink supply method, for an ink-jet recording apparatus that includes a recording head, which is mounted on a carriage and is reciprocally moved across the width of a recording sheet, a sub-tank to which ink from an ink cartridge is supplied and from which ink is supplied to said recording head, ink

quantity detection means for detecting the amount of ink retained in said sub-tank, and a consumed ink quantity counter for calculating the total amount of ink ejected or discharged by said recording head, comprising:

an ink quantity detection step of permitting said ink quantity detection means to detect the amount of ink retained in said sub-tank;

a consumed ink quantity determination step of, when a low ink state in which the amount of ink retained in said sub-tank is smaller than a predetermined value is detected at said ink quantity detection step, examining a ink amount total held by said consumed ink quantity counter to determine whether said ink amount total has reached a predetermined ink amount total; and

an ink supply step of, when it is ascertained at said consumed ink quantity determination step that said ink amount total has reached said predetermined ink amount total, supplying ink from said ink cartridge to said sub-tank.

[Claim 9]

An ink supply method according to claim 8, wherein, when said ink supply step is performed and said ink quantity detection means detects a full ink state in which the amount of ink has reached said predetermined value, said ink supply halting step of halting the supply of ink from said ink cartridge to said sub-tank is performed.

[Claim 10]

An ink supply method according to claim 9, wherein, as

said ink supply halting step is performed, said ink amount total held by said consumed ink quantity recording means is reset.

[Detailed Description Of The Invention]

[0001]

[Technical Field To Which The Invention Belongs]

The present invention relates to an ink-jet recording apparatus wherein sub-tanks for supplying ink to a recording head are mounted on a carriage, and relates in particular to an ink-jet recording apparatus that can control, within an appropriate range, the amount of ink retained in each sub-tank and to a method for replenishing ink in the sub-tanks for the ink-jet recording apparatus.

[0002]

[Prior Art]

A conventional ink-jet recording apparatus of a serial printing type comprises: an ink-jet recording head, which is mounted on a carriage and is moved across the width of a recording sheet; and paper feeding means, for moving the recording sheet in a direction perpendicular to the direction in which the recording head is moved. Based on printing data, the ink-jet recording apparatus, when printing, ejects ink droplets from the recording head onto a recording sheet.

[0003]

For this type of recording apparatus, which is provided for office or for professional use, ink cartridges having large capacities must be positioned so that they can cope

with the printing of a comparatively large amount of data. Therefore, a recording apparatus is provided wherein main tanks, which serve as ink cartridges, are loaded into cartridge holders arranged on the main body of the apparatus.

[0004]

In a thus arranged recording apparatus, sub-tanks are located on a carriage on which a recording head is mounted, and ink in the sub-tanks, which supply ink to the recording head, is replenished via ink tubes extending from the main tanks to the sub-tanks.

[0005]

[Problems That The Invention Is To Solve] Recently, the demand has increased for large recording apparatuses that can be used for the printing of data on large sheets of paper and that provide extended scanning distances for carriages. For such a recording apparatus, more nozzles are formed in the recording head in order to improve throughput. Further, also in order to improve throughput, a recording apparatus is requested wherein during the performance of the printing process, the main tanks can, as needed, concurrently replenish the ink in the sub-tanks mounted on the recording head carriage, so that a stable supply of ink for the recording head can be provided by the sub-tanks.

[0006]

In this recording apparatus, the length of an ink tube used to connect a main tank and a sub-tank is naturally extended. Further, as is described above, since an increased number

of nozzles are formed in the recording head, ink consumption is increased, as is the pressure on the ink passing through each ink tube communicating with a main tank and a sub-tank. Accordingly, as a technical shortcoming, the ink supply available for replenishing the sub-tanks falls short of that which is actually required.

[0007]

For the resolution of this shortcoming, the present inventor proposes an appropriate recording apparatus. In this apparatus, by introducing air under pressure into a main tank, the flow of ink from the main tank to a corresponding sub-tank is forcibly generated, and a required and adequate amount of ink is supplied to replenish the sub-tank. In this case, ink quantity detection means must be arranged in the sub-tank in order to constantly maintain, within a predetermined range, the volume of the ink stored therein. By using the quantity of the ink output to monitor the detection means (hereinafter also referred to as surface detection means), an ink supply valve that is located along an ink path leading from a main tank to a sub-tank is opened or closed. This configuration has also been proposed by the present inventor.

[0008]

Preferably, an ink quantity detection means includes: a permanent magnet, attached to a float member stored in a sub-tank, and a Hall device, which is positioned on the side wall of the sub-tank to detect and measure the magnetic force of the permanent magnet. With this arrangement, a low ink

state, wherein the amount of ink retained in the sub-tank is less than a predetermined value, or a full ink state, wherein the amount of ink retained in the sub-tank is equal to or greater than the predetermined value, can be detected from the output of the Hall device.

[0009]

When the ink quantity detection means detects a low ink state, the ink supply valve, which is located along the ink path leading from the main tank to the sub-tank, is opened, so that replenishment of the ink in the sub-tank can be effected. Then, when the ink quantity detection means detects a full ink state, the ink supply valve is closed, thereby halting the replenishment process. By repeatedly performing this process, the volume of the ink retained in a sub-tank can be maintained within a predetermined range.

[0010]

The ink amount detection means is employed to supply or halt the supply of ink to the sub-tank, the following process is repeated; when it detects the low ink state, the ink is immediately supplied to the sub-tank, and when the full ink state is detected, the supply of ink to the sub-tank is halted. That is, since during printing a low ink state can be detected and the replenishment of ink effected after only a small amount of ink has been consumed, and since a full ink state can be detected after only a small amount of ink has been supplied, the on and off supply of ink is rapidly and frequently, cyclically repeated.

[0011]

As one example problem that may arise when a recording apparatus is thus arranged, as the carriage reciprocates, rippling of the ink in the sub-tanks mounted on the carriage may occur and may result in the available ink volumes being erroneously detected, an unintended and undesirable condition that may also be encountered when for some other reason vibration of the recording apparatus occurs. Therefore, if due to this effect low ink states are erroneously detected, even though the sub-tanks are actually filled, the initiation of the resulting ink replenishment process may cause the sub-tanks to overflow, and may in some cases precipitously produce a critical problem by causing ink to leak from the sub-tanks.

[0012]

Figs. 9 and 10 are specific diagrams showing an example wherein the ink quantity detection means has erroneously and unpropitiously detected the ink level in a sub-tank. First, in the example in Fig. 9, one Hall device has been provided to detect the strength of the magnetic field of a permanent magnet attached to a float member. With this arrangement, when only a small amount of ink remains in the sub-tank, the strength of the magnetic force acting on the Hall device is very weak. In this case, as is indicated in region (1) in Fig. 9, the Hall device is OFF, identifying a low ink state, and the operation performed to supply ink to the sub-tank is initiated.

[0013]

As the ink supply operation raises the level of the ink in the sub-tank, the float member is accordingly raised, until a predetermined strength is attained by the magnetic force acting // ?>field detected by the Hall device and renders the Hall device ON, thereby identifying a full ink state, which in Fig. 9 is indicated by a shaded region. When the full ink state is identified, the supply of ink to the sub-tank is halted, after which, if rippling of the ink in the sub-tank occurs, as is described above, because of the reciprocation of the carriage during printing, or as the result of other vibrations, a detection process is performed for region (2) in Fig. 9.

[0014]

In this case, since the magnetic force acting on the Hall device is reduced, the Hall device is rendered OFF, erroneously detecting a low ink state. Therefore, resupply of ink to the sub-tank is initiated, and an excessive amount of ink flows into the sub-tank. Therefore, since the Hall device OFF state is thereby maintained, accordingly, ink leaks from the sub-tank, producing a critical problem.

[0015]

To eliminate this problem, two Hall devices may be provided in the direction in which the permanent magnet moves (vertically). This arrangement is shown in Fig. 10. As is pictured in Fig. 10A, the magnetic force detection regions of the upper and lower Hall devices are overlapped, with the region wherein the upper Hall device is rendered ON indicated by a U, and

the region wherein the lower Hall device is rendered ON indicated by an L. With this arrangement, the ink level in the sub-tank can be detected for four states, upper OFF/lower OFF, upper OFF/lower ON, upper ON/lower ON and upper ON/lower OFF, in consonance with the combined outputs of the upper and lower Hall devices.

[0016]

However, because of variances in the magnetic detection sensitivity exhibited by the Hall devices, and variances due to assembly errors in the distances between the permanent magnet and the Hall devices, the magnetic detection regions of the upper and lower Hall devices may not overlap, as is shown in Fig. 10B. In the state shown in Fig. 10B, a region (3), whereat both Hall devices are rendered OFF, is generated between the magnetic detection regions of the Hall devices, which are depicted as shaded portions.

[0017]

Therefore, after a full ink state has been detected during printing, and reciprocation of the carriage, or other vibration sources, causes rippling of the ink in the sub-tank, the region (3) is generated and a low ink state is erroneously detected. In this case, since ink is supplied to the sub-tank, a sub-tank overflow error occurs, and the printing must be halted to perform maintenance.

[0018]

As is described above, when an ink quantity detection means comprising a Hall device and a permanent magnet attached

to a float member is employed, the first problem that occurs is that the supply of ink to the sub-tank is frequently repeated, and accordingly, the second problem that occurs is that vibration causes the amount of ink in the sub-tank to be erroneously detected.

[0019]

To resolve the above technical problems, it is one objective of the present invention to provide an ink-jet recording apparatus that can set a satisfactory long interval for the supply of ink to sub-tanks and can thus prevent the erroneous detection of the ink quantities in the sub-tanks, which is caused by a factor such as vibration, and a control method for supplying ink to the sub-tanks of the ink-recording apparatus.

[0020]

[Means For Solving The Problems]

To achieve the above objective, according to one aspect of the present invention, an ink-jet recording apparatus comprises:

a recording head, which, being mounted on a carriage, is reciprocally moved across the width of a recording sheet;

a sub-tank, which, being mounted on the carriage adjacent to the recording head, is supplied with ink from an ink cartridge and supplies the ink to the recording head;

wherein the sub-tank includes

ink level detection means, for at the least detecting a low ink state, in which the amount of ink retained in the

sub-tank is smaller than a predetermined value, and a full ink state, in which the amount of ink retained in the sub-tank reaches the predetermined value, and

a consumed ink quantity counter, for acquiring, as a total, the quantity of ink ejected or discharged by the recording head, and

wherein, when a low ink state has been detected by the ink level detection means and the value acquired by the consumed ink quantity counter has reached a predetermined count level, ink is supplied to the sub-tank by the ink cartridge.

[0021]

In this case, it is preferable that the predetermined ink amount total held by the consumed ink quantity counter be set equal to or smaller than "an effective ink amount in the sub-tank - the amount of ink to be ejected by the recording head during one cleaning operation".

[0022]

According to another aspect of the invention, an ink supply valve is located along an ink supply path extending from the ink cartridge to the sub-tank, and when the ink supply valve is opened, ink is supplied to the sub-tank.

[0023]

According to an additional aspect of the invention, an ink pack, composed of a flexible material in which ink is enclosed, is stored in the ink cartridge, the outer block member of which is airtight. Air under pressure is introduced by a pneumatic pump into a space that is defined by the ink

pack and the outer block member of the ink cartridge, and under the air pressure, ink from the ink cartridge is supplied to the sub-tank.

[0024]

It is preferable that the ink quantity detection means detect an overflow state in which the amount of ink retained is greater than in the full ink state. When an overflow state is detected, an operation is initiated for opening the ink supply valve and for releasing, to the atmosphere, the air pressurized by the pneumatic pump.

[0025]

It is also preferable that the ink quantity detection means for detecting the quantity of ink retained in the sub-tank include:

a float member, which floats on ink that is supplied to the sub-tank; and

magnetoelectric conversion means, for utilizing the magnetic force exerted by a permanent magnet, mounted on the float member, to generate, in consonance with the afloat positioning of the float member relative to the magnetoelectric conversion means, an electric output.

[0026]

The ink quantity counter obtains the amount of ink consumed by performing a multiplication process using a coefficient based on the number of ink droplets ejected by the recording head, or by performing a multiplication process, using the coefficient, each time a cleaning operation is performed to

attract and discharge ink from the recording head.

[0027]

According to a further aspect of the invention, an ink supply method, for an ink-jet recording apparatus that includes a recording head, which is mounted on a carriage and is reciprocally moved across the width of a recording sheet, a sub-tank to which ink from an ink cartridge is supplied and from which ink is supplied to the recording head, ink quantity detection means for detecting the amount of ink retained in the sub-tank, and a consumed ink quantity counter for calculating the total amount of ink ejected or discharged by the recording head, comprises:

an ink quantity detection step of permitting the ink quantity detection means to detect the amount of ink retained in the sub-tank;

a consumed ink quantity determination step of, when a low ink state in which the amount of ink retained in the sub-tank is smaller than a predetermined value is detected at the ink quantity detection step, examining a ink amount total held by the consumed ink quantity counter to determine whether the ink amount total has reached a predetermined ink amount total; and

an ink supply step of, when it is ascertained at the consumed ink quantity determination step that the ink amount total has reached the predetermined ink amount total, supplying ink from the ink cartridge to the sub-tank.

[0028]

In this case, it is preferable that, when the ink supply step is performed and the ink quantity detection means detects a full ink state in which the amount of ink has reached the predetermined value, the ink supply halting step of halting the supply of ink from the ink cartridge to the sub-tank is performed. As the ink supply halting step is performed, the ink amount total held by the consumed ink quantity recording means is reset.

[0029]

According to the ink-jet recording apparatus that employs the method for supplying ink to the sub-tank, first, the ink quantity detection means detects the amount of ink retained in the sub-tank. In this case, because of an above described factor, such as the rippling of ink in the sub-tank or an external vibration, a low ink state may be erroneously detected even though the sub-tank is full of ink.

[0030]

When the ink quantity detection means detects a low ink state, the ink amount total held by the consumed ink quantity counter is referred to. The consumed ink quantity counter is reset when the ink quantity detection means has previously detected a full ink state. Therefore, when the ink amount total held by the consumed ink quantity counter has not reached a predetermined ink amount total even though the ink quantity detection means has detected a low ink state, it can be assumed that either a very small amount of ink has been consumed, or an erroneous detection by the ink quantity detection means

has occurred. Thus, in this case, the supply of ink to the sub-tank by the ink cartridge is inhibited.

[0031]

When the ink quantity detection means detects a low ink state and when the ink amount total held by the consumed ink quantity counter has reached the predetermined ink amount total, it can be assumed that the amount of ink retained in the sub-tank has been considerably reduced. Therefore, in this case, the supply of ink to the sub-tank by the ink cartridge is initiated.

[0032]

Through the exercise of this control, the supply of ink to the sub-tank is initiated when it has been confirmed that a predetermined amount of the ink in the sub-tank has been consumed. Thus, a problem involving the frequent, repeated resupply of ink from the ink cartridge to the sub-tank can be avoided, and a satisfactorily long interval can be obtained for the supply of ink to the sub-tank.

[0033]

Since the supply of ink to the sub-tank is controlled, the erroneous detection of the amount of ink in the sub-tank, which is the result of vibration or another factor, can be prevented, and the amount of ink in the sub-tank can be constantly maintained within a specific range. Thus, a normal printing operation can be continuously performed.

[0034]

The predetermined ink amount total is set for the consumed

ink quantity counter to establish a relationship wherein the quantity of ink ejected by the recording head in the printing operation + the ink quantity ejected from the recording head by the flashing operation + the ink quantity discharged from the recording head by one cleaning operation < the effective ink quantity in the sub-tank". Therefore, even when the printing of a predetermined amount of data, a flushing operation and one cleaning operation are performed following the supply of ink to the sub-tank, the ink in the sub-tank would not be exhausted, so that the problem that would arise were air to enter an empty ink flow path leading from a sub-tank to the recording head can be avoided.

[0035]

[Mode for Carrying Out The Invention]

An ink-jet recording apparatus that employs a method for supplying ink to sub-tanks in accordance with the preferred embodiment of the present invention will now be described. Fig. 1 is a top view of the basic configuration of the ink-jet recording apparatus. In Fig. 1, a carriage 1 is guided to a scan guide member 4 via a timing belt 3 that is driven by a carriage motor 2, and is reciprocally moved in the main scanning direction, the longitudinal direction of a paper feed member 5, i.e., across the width of a recording sheet. Although not shown in Fig. 1, an ink-jet recording head 6, which will be described later, is mounted on the face of the carriage 1 opposite the paper feed member 5.

[0036]

Sub-tanks 7a to 7d are mounted on the carriage 1 to supply ink to the recording head 6. In this embodiment, four sub-tanks 7a to 7d are prepared for corresponding inks (e.g., black, yellow, cyan and magenta inks) for the temporarily storage of these inks.

[0037]

The black and the other colored inks are supplied to the sub-tanks 7a to 7d by main tanks 9a to 9d, which are ink cartridges loaded into a cartridge holder 8 at the end of the apparatus, are connected to flexible ink supply tubes 10 constituting ink supply paths.

[0038]

Capping means 11, for sealing the nozzle formation face of the recording head 6 is located in a non-printing region (home position) on the route along which the carriage 1 reciprocates. Further, a capping member 11a composed of an elastic member, such as rubber, is located on the top of the capping means 11, so that it can be closely attached to the nozzle formation face of the recording head 6. When the carriage 1 is moved to the home position, the capping member 11a is used to close the nozzle formation face of the recording head 6.

[0039]

While the recording apparatus is halted, the capping member 11a serves as a lid that seals the nozzle formation face of the recording head 6 and prevents the nozzle openings from being drying out. One end of the tube of a vacuum pump (tube

pump), which will be described later, is connected to the capping member 11a, so that, upon the application to the recording head 6 of a negative pressure produced by the vacuum pump, a cleaning operation is performed during which ink is discharged from the recording head 6.

[0040]

A wiping member 12, which is a strip composed of an elastic member, such as rubber, is located in a printing region adjacent to the capping means 11, and as needed, the wiping member 12 is used to clean the nozzle formation means of the recording head 6.

[0041]

Fig. 2 is a specific diagram primarily showing the configuration of an ink supply system mounted on the recording apparatus in Fig. 1. The ink supply system will now be described while referring to Fig. 1 and Fig. 2, for which the same reference numerals as in Fig. 1 are used. In Figs. 1 and 2, compressed air supplied by a pneumatic pump 21 is piped to a pressure control valve (hereinafter also referred to simply as a regulator) 22 that serves as a relief valve, and from there, via a pressure detector 23, to the main tanks 9a to 9d (in Fig. 2, these tanks are collectively and simply referred to as the main tank 9; a term that hereinafter may be employed).

[0042]

In this embodiment, an air flow path leading from the pressure detector 23 is branched to carry compressed air to the main tank 9 loaded in the cartridge holder 8.

[0043]

When it is determined that due to a specific factor the pressure of the compressed air supplied by the pneumatic pump 21 is excessive, air is bled off by the pressure control valve 22 to reduce, and maintain within a predetermined range, the pressure in the main tanks 9a to 9b. As will be described later, the pressure control valve 22, upon receiving an appropriate instruction signal, also serves as a pressure regulator that releases compressed air to the atmosphere.

[0044]

The pressure detector 23 measures the pressure of the compressed air and employs the results to control the operation of the pneumatic pump 21. Specifically, when the strength of the pressure of the compressed air exceeds a predetermined level, the pressure detector 23 halts the driving of the pneumatic pump 21, and when the strength of the pressure of the compressed air is equal to or less than the predetermined level, the detector 23 drives the pneumatic pump 21. In this manner, a predetermined range is maintained for the pressure of the compressed air in the main tanks 9a to 9d.

[0045]

As is shown in the schematic structure in Fig. 2, a case that forms the outer block of the main tank 9 is airtight, and an ink pack 24, composed of flexible material in which ink is enclosed, is stored inside. The space defined by the main tank 9 and the ink pack 24 forms a pressure chamber 25, and compressed air is supplied to this pressure chamber 25

via the pressure detector 23.

[0046]

With this arrangement, when air pressure is exerted on the ink packs 24 stored in the main tanks 9a to 9d, ink flows from the main tanks 9a to 9d to the sub-tanks 7a to 7d under a predetermined pressure. A storage device 27, such as an EEPROM, for storing information for the main tank 9 that serves as an ink cartridge, is located in a part of the case thereof. As will be described later, data concerning the amount of ink remaining in the main tank 9 is written in the storage device 27.

[0047]

A terminal 28 located in a part of the main tank 9 is used to read and write information relative to the storage device 27. When the main tank 9 is loaded into the recording apparatus 1, the terminal 8 is electrically connected to the recording apparatus 1 for the exchange of information concerning the amount of ink remaining in the main tank 9.

[0048]

The ink in the main tanks 9a to 9d is supplied under pressure, via the ink supply valves 26 and along the ink supply tubes 20, to the sub-tanks 7a to 7d mounted on the carriage 1 (in Fig. 2, these sub-tanks are collectively and simply referred to as the sub-tank 7; a term that hereinafter may be employed).

[0049]

A detailed explanation will be given later for the structure of the sub-tank 7 in Fig. 2. As the basic structure, a float

member 31 is internally arranged in the sub-tank 7 and a permanent magnet 32 is attached to a part of the float member 31. Two magnetoelectric converters 33a and 33b, which are Hall devices, are vertically attached, in line, to a substrate 34 along the side wall of the sub-tank 7.

[0050]

With this arrangement, output generation means is provided wherein the Hall devices 33a and 33b utilize the magnetic force exerted by the permanent magnet 33, mounted on the float member 31, to generate, in consonance with the afloat positioning of the float member 31 relative to the Hall devices 33a and 33b, a variable electric output. This means serves to detect the ink quantity in the sub-tank 7 for which the float member 31 is provided, i.e., it provides the ink level detection function.

[0051]

In this embodiment, depending on the combined output states of the two Hall devices 33a and 33b, the ink quantity detection means identifies, in three steps, as the quantity of ink remaining in the sub-tank 7, a low ink state, a full ink state and an overflow state, beginning with a small quantity and proceeding to a large quantity of ink. Whereas, in this embodiment, consumed ink quantity calculation means is provided for calculating for the sub-tank the amount of ink that has been consumed, as will be described later, when the ink quantity detection means indicates a low ink state, and when the consumed ink quantity calculation means determines that a predetermined

amount or more of ink has been consumed, the ink supply valve 26 is opened. As a result, ink in the pressurized main tank 9 is supplied to the pertinent sub-tank 7 from which the ink has been exhausted.

[0052]

When the ink in the sub-tank 7 reaches a predetermined level, and the ink quantity detection means detects a full ink state, the ink supply valve 26 is closed. By repeating this process, ink from the main tank 9 is continually supplied to the sub-tank 7, and a constant, predetermined amount of ink is retained in the sub-tank 7. The ink quantity detection means detects an overflow state when it determines that more ink has been supplied than is required for a full ink state.

[0053]

As is shown in Fig. 2, ink from each sub-tank 7 is supplied to the recording head 6, through a valve 35 and along a tube 36 connected thereto, and based on print data that is transmitted to the actuator (not shown) of the recording head 6, ink droplets are ejected from nozzle openings 6a that are formed in the nozzle formation face of the recording head 6. A tube, which is connected to the capping means 11 in Fig. 2, extends to a vacuum pump (tube pump), which will be described later.

[0054]

Fig. 3 is a partially-cutaway perspective view of the sub-tank 7 viewed in a direction leading from one face thereof, and Fig. 4 is a side view in the same direction. In Figs. 3 and 4, previously used component reference numerals are

employed to denote corresponding components.

[0055]

The sub-tank 7 is formed substantially as a rectangular parallelepiped, and overall is flat. The outer block of the sub-tank 7 is a box member 41, integrally formed of one side wall 41a and a continuing circumferential side wall 41b. Using thermal fusing means, a film member 42 (see Fig. 4) composed of a transparent resin material is closely attached around the circumference of the opening in the box member 41, and defined inside is an ink retaining space 43 enclosed by the box member 41 and the film member 42.

[0056]

A support shaft 44 is integrally formed with the box member 41 and projects inward, toward the ink retaining space 43, from the side wall 41a of the box member 41. In the ink retaining space 43, the float member 31 rotates freely at the support shaft 44 in the gravitational direction. In this embodiment, the support shaft 44 is located near the horizontal end in the ink retaining space 43, and the float member 31 is integrally formed with the free, movable end of a support arm member 45, which is rotated at the support shaft 44.

[0057]

As is shown in Fig. 4, the permanent magnet 32 is attached to the free end of the support arm member 45, so that, when the support arm member 45 is positioned substantially horizontally, the magnet 32 is located in the ink retaining space 43, near the other end in the horizontal direction,

i.e., is located nearer the Hall devices 33a and 33b that are mounted on the substrate 34 arranged along the side wall of the sub-tank 7.

[0058]

An ink supply port 46 is formed, in the gravitational direction, at the bottom of the sub-tank 7, i.e., at the bottom of the circumferential side wall 41b in this embodiment, and ink from the main tank 9 is supplied to the ink retaining space 43 along the tube 10 connected to the ink supply port 46. Since, as is described above, the ink supply port 46 is formed in the bottom of the sub-tank 7 in the gravitational direction, the ink in the main tank 9 is supplied from the bottom of the ink retaining space 43, and thus, in the ink retaining space 43, the generation of ink bubbles at the ink supply inlet is prevented.

[0059]

Further, multiple linear rib members 47 are arranged in the portion of the sub-tank 7 that excludes a portion through which the float member 31 and the support arm member 45 move. The rib members 47 are used to suppress the rippling of ink in the sub tank 7 as the carriage is moved. In this embodiment, the rib members 47 are integrally formed with the side wall 41a of the box member 41 constituting the sub-tank 7, so that they project inward from the side wall 41a into the ink retaining space 43. With these rib members 47, the rippling of ink in the sub-tank 7 can be suppressed to a degree, and the accuracy with which the Hall device detects the amount of ink retained

in the sub-tank 7 can be improved.

[0060]

In addition, as is shown in Fig. 4, an ink outlet port 48 is formed in the sub-tank 7 near the ink supply port 46, and a filter member 49, shaped like a pentagon (a home base shape), for trapping foreign substances is positioned so that it covers the ink outlet port 48. Therefore, ink retained in the sub-tank 7 is guided through the filter member 49 to the ink outlet port 48.

[0061]

The ink discharged through the ink outlet port 48 is transmitted along the reverse face of the side wall 41a to the valve 35, which is located under the bottom of the sub-tank 7. Then, from the valve 35, the ink is guided along the reverse face of the side wall 41a to the connection port 53 for the tube 36 that leads to the recording head 6.

[0062]

An inclined groove 61 that communicates with the ink retaining space 43 is formed in the upper half portion of the sub-tank 7. An air through hole 62 is formed in the upper end of the groove 61, i.e., high up in the sub-tank 7 in the gravitational direction, and communicates with the reverse face of the side wall 41a of the sub-tank 7. It should be noted that on the reverse face of the side wall 41a the through hole 62 is closed with a water repellent film that permits the passage of air but prevents the passage of ink.

[0063]

As is shown in Fig. 4, a recessed portion 41c used for positioning the Hall devices 33a and 33b is formed in the side wall of the sub-tank 7. Since the recessed portion 41c is formed in the side wall of the sub-tank 7, that wall is thinner, and the distance between the Hall device 33a or 33b and the trajectory along which the permanent magnet 32 attached to the float member 31 travels is reduced. As a result, the sensitivity with which the Hall devices 33a and 33b detect the magnetic force exerted by the permanent magnet 33 is improved, thereby increasing the accuracy with which the quantity of ink in the sub-tank 7 can be measured by utilizing the effect of gravity on the attitude of the float member 31.

[0064]

A through hole 67 is formed in a part of the sub-tank 7. By using a support shaft (not shown) that passes through the through hole 67 of the sub-tank 7, the sub-tanks 7 can be arranged in parallel to constitute a sub-tank unit.

[0065]

Figs. 5 and 6 are partial cross-sectional views of the structure of the pressure control valve 22 that serves as a pressure regulator, with the essential portion cut away. In Fig. 5, the configuration shown is when the pressure control valve 22 is functioning normally, and in Fig. 6, the configuration shown is when air is being released to relieve pressure.

[0066]

In Figs. 5 and 6, a valve unit 81 includes an upper case

81a and a lower case 81b, in which space is defined internally, into which it is divided. A diaphragm valve 82, a valve member, is located at the junction of the upper case 81a and the lower case 81b. The diaphragm valve 82 is a rubber disk, and its circumferential edge is sandwiched between the upper case 81a and the lower case 81b. In an airtight condition, an air chamber 83 is formed in the internal space defined in the lower case 81b.

[0067]

A pair of connection pipes 84a and 84b, which communicate with the air chamber 83, are also formed in the lower case 81b. These connection pipes 84a and 84b are connected to the air paths extending from the pneumatic pump 21 to the main tanks 9, which are the ink cartridges. Therefore, air from the pneumatic pump 21 passes along the path indicated by the arrow in Fig. 6 through the air chamber 83 to the pressure detector 23 and the main tanks 9 that will be described later. An air through hole 84c is formed in the center of the lower case 81b and ends substantially in the center of the diaphragm valve 82 at the end of the communication hole 84c that is opened to the air chamber 83.

[0068]

A drive shaft 85, which moves vertically, is located in the upper case 81a, and the top face of the diaphragm valve 82 is supported by the lower end of the drive shaft 85. An annular spring seat 86 is fitted over the drive shaft 85 and a coil spring (compression spring) 87 is located between the

spring seat 86 and the upper space in the upper case 81a. The center of the diaphragm 82 is compressed by the spring member 87 so that it covers the open end of the through hole 84c.

[0069]

An engagement head 88, located at the upper end of the drive shaft 85, engages a drive lever 90, which is supported by a shaft 89, in the middle, between one end of the drive lever 90 and the shaft 89. An operating rod 91a, for an electromagnetic plunger 91, is coupled with the other end of the drive lever 90, and the driving force produced by the electromagnetic plunger 91 is applied to the operating rod 91a. Furthermore, one end of a spring member, i.e., a tension spring 93, is attached to the other end of the drive lever 90 adjacent to the shaft 89, and rotates the drive lever 90 to the left at the shaft 89.

[0070]

With this arrangement, when the electromagnetic plunger 91 is electrified, as is shown in Fig. 5, one end of the drive lever 90 is pulled down against the urging force of the tension spring 93. Therefore, the engagement head 88, which is attached to the drive shaft 85 of the valve unit 81, floats free of the drive lever 90, while the urging force of the spring member 87 and the flexible force of the diaphragm valve 82 close the air through hole 84c.

[0071]

When in the valve open state the pneumatic pump 21 is

driven, and when the pressure in the air pressure chamber 83 exceeds a predetermined value, i.e., when the pressure exceeds an injection-valve closing pressure exerted by the urging force of the spring member 87 and the flexible force of the diaphragm valve 82, the diaphragm valve 82 is raised by the air pressure, opening the through hole 84c. Thus, the compressed air is forcefully discharged from the air chamber 83 through the air through hole 84c, and the pressure is released. [0072]

When the air pressure is reduced to a predetermined value, the valve closing operation is again performed by the urging force exerted by the spring member 87 and the flexible force of the diaphragm valve 82. As a result, the pressure along the air path extending from the pneumatic pump 21 to the main tank 9 is controlled within a predetermined range. As is described above, when the air pressure exceeds a predetermined value in the conductive state in Fig. 5, wherein the electromagnetic plunger 91 is operated, the diaphragm valve 82 is repetitively opened and closed and functions as a pressure control valve. Since this pressure control function is provided, a problem can be avoided that arises when the air pressurization control malfunctions, and an abnormally high air pressure is applied to and ruptures the ink pack in the main tank. [0073]

When the supply of power to the electromagnetic plunger 91 is halted, as is shown in Fig. 6, the drive lever 90 is rotated to the left by the tractive force exerted by the tension

spring 93, pulling the drive shaft 85 in the valve unit 81 upward against the urging force exerted by the spring member 87 and the flexible force of the diaphragm valve 82 in the valve unit 81. Thus, compressed air is forcibly discharged from the air chamber 83 at the through hole 84c, and an air released state is obtained.

[0074]

According to the arrangement in Figs. 5 and 6, since an air released state is obtained, as in Fig. 6, when the supply of power to the electromagnetic plunger 91 is halted, this state is immediately provided when the recording apparatus is powered off and no further power is supplied to the electromagnetic plunger 91. Thus, in the OFF state, when the recording apparatus is not powered on, the compressed air in the main tank is automatically released. Therefore, by halting the operation of the recording apparatus, the problem presented by the leakage of ink induced by compressed air retained in the main tank 9 can be avoided.

[0075]

Fig. 7 is a diagram showing an example control circuit constituting a part of the means provided to supply ink to the sub-tank when the method of the invention is implemented. In Fig. 7, previously used component reference numerals are again employed to denote corresponding components, and no further explanation for them will be given. As is shown in Fig. 7, a vacuum pump 15 is connected to the capping means 6, and on its discharge side is connected to a waste water

tank 16.

[0076]

In Fig. 7, based on print data received from a host computer, print control means 100 generates bit map data, and based on the bit map data, head drive means 101 generates a drive signal for the ejection of ink droplets from the recording head 6 mounted on the carriage 1. In addition to the drive signal based on the print data, the head drive means 101 also outputs a drive signal for a flushing operation upon receiving a flushing instruction signal from flushing control means 102.

[0077]

Upon receiving a control signal from cleaning instruction detection means 104, cleaning control means 103 exercises control of pump drive means 105 for driving the vacuum pump 15. And when a cleaning instruction switch 106 arranged on the console panel of the recording apparatus is manipulated, operation of the cleaning instruction detection means 104 is initiated for the performance of a manual cleaning operation. In addition, upon receiving a control signal from the print control means 100, the cleaning control means 103 performs the timer cleaning operation to permit the pump drive means 105 to drive the vacuum pump 15 for every predetermined time.

[0078]

A control signal is supplied to consumed ink quantity calculation means 107 by the print control means 100, the flushing control means 102 and the cleaning control means

103. One function of the consumed ink quantity calculation means 107 is the calculation for each sub-tank 7 of the amount of ink that has been consumed. For this purpose, the consumed ink amount calculation means 107 receives data from the print control means 100 on the number of ink droplets that are ejected, based on print data, by the recording head 6, data from the flushing control means 102 on the number of ink droplets ejected during a flushing operation by the recording head 6, and data from the cleaning control means 103 for each time ink is attracted for a cleaning operation and is discharged by the recording head 6.

[0079]

Upon receiving these data, based on the number of ink droplets ejected during the printing operation or the flushing operation by the recording head 6, or based on the ink discharge process performed for each cleaning operation, the consumed ink quantity calculation means 107 accesses coefficient setting means 108, and performs the multiplication of a corresponding coefficient to calculate for each sub-tank the amount of ink that has been consumed.

[0080]

The amount of ink consumed that is thus obtained for each sub-tank 7 is transmitted to an ink consumption counter 109, and the ink amount total is incremented. Then, as is described above, the ink quantity detection means, which includes the Hall devices 33a and 33b, for detecting the amount of ink in the sub-tank 7 detects a low ink state. When the value

held by the ink consumption counter 109 reaches a predetermined ink amount total, it is assumed that the ink in the sub-tank 7 has been exhausted. Therefore, the ink supply valve 26 is opened and ink from the main tank 9 is supplied to the sub-tank 7.

[0081]

When the ink has been supplied and by detecting the electric output by the Hall devices 33a and 33b it is determined that the amount of ink retained in the sub-tank 7 has reached a predetermined value (a full ink state), the ink supply valve 26 is closed, as is described above, and at the same time, the ink consumption counter 109 for the sub-tank 7 is reset.

[0082]

The ink consumption counter 109 for the sub-tank 7 is so designed that it transmits, to a remaining ink counter 110 in the main tank 9, information concerning the amount of ink held in the sub-tank 7. Further, data for the amount of ink remaining in the main tank 9, which is stored in the storage device 27 mounted in the loaded main tank 9, is set in advance by write/read means 111 in the remaining ink counter 110 for the main tank 9.

[0083]

The latest ink amount total, held by the ink consumption counter 109 for the sub-tank 7 immediately before the counter 109 is reset, is transmitted to the remaining ink counter 110 for the main tank 9, and is subtracted from the ink amount total that indicates the amount of ink remaining in the main

tank 9. Thus, the numerical value held for the main tank 9 by the remaining ink counter 110 is decremented as ink is consumed, and the resultant value data is written, using the write/read means 111, in the storage device 27 mounted in the main tank 9. Therefore, when data is read from the storage device mounted in the ink cartridge that serves as the main tank 9, the amount of ink remaining in the cartridge can be immediately ascertained.

[0084]

A control signal for opening or closing the ink supply valve 26 is also transmitted to timer means 112 by the consumed ink counter 109 for the sub-tank 7. The timer means 112 initiates a time count at the same time as the ink supply valve 26 is opened. When the level state detected by the Hall devices 33a and 33b still indicates a low ink state, even though a set time has elapsed, it can be assumed that the main tank 9 is in the ink exhausted (ink-out) state, or that for some reason an obstacle has appeared in the ink supply system. In this case, an error message is displayed on display means 13, as will be described later.

[0085]

Fig. 8 is a flowchart showing the control routine for the above arranged recording apparatus for employing the method for supplying ink to the sub-tank 7. This control routine is performed independently for each main tank 9, which is an ink cartridge, and for a corresponding sub-tank 7. The control routine is initiated when the recording apparatus

is powered on, or every five seconds, for example, during printing, in order to determine whether it is necessary for ink from the main tank 9 to be supplied to the sub-tank 7.
[0086]

First, when the recording apparatus is powered on, at step S11 a supply halt flag is reset. That is, when the supply halt flag is reset, the supply of ink to the sub-tank 7 is prepared. Then, at step S13, the level of the ink is determined, i.e., the amount of ink in the sub-tank 7 is determined by using the combined outputs of the two Hall devices 33a and 33b, which constitute the ink quantity detection means.
[0087]

Whereas, during the printing, as is described above, the process at step S12 is performed every five seconds to determine whether the supply halt flag is set or reset. When the supply halt flag is set, the ink supply to the sub-tank 7 is not initiated, and at step S14, the supply valve 26 is closed. Program control thereafter returns. When it is ascertained at step S12 that the supply halt flag is reset, at step S13 the level of ink in the sub-tank 7 is detected.
[0088]

At step S13, the three states described above, i.e., the ink overflow state, the full ink state and the low ink state, are identified. When the overflow state is detected, program control advances to step S15 to set the supply halt flag. Then, at step S16 the supply valve 26 is closed, and at step S17, the relief valve 22 is opened. That is, in this case,

as explained while referring to Fig. 6, the supply of power to the electromagnetic plunger 91 is halted, and the valve unit 81 is opened by the tension spring 93. As a result, the air compressed by the pneumatic pump 21 is released to the atmosphere.

[0089]

Under this control, the supply of the compressed air to each main tank 9 is halted, and the supply of ink to each sub-tank 7 is disabled. Further, an error message indicating that maintenance is required is displayed on the display means 113.

[0090]

When a full ink state is detected at step S13, the supply of ink to the sub-tank 7 is not required, and program control returns. When a low ink state is detected at step S13, program control advances to step S18, and the value held by the consumed ink counter 109 is examined to determine whether for the sub-tank the amount of ink consumed is equal to or greater than "Ch*".

[0091]

"Ch*" is a predetermined value set as a parameter, and corresponds to "the amount of ink ejected by the recording head 6 for printing + the amount of ink ejected by the recording head during a flushing operation". The quantity of ink is so controlled that, even when the amount of ink used for ejection or discharging is subtracted from the value indicating a full ink state and when the amount of ink used for cleaning is further subtracted from the resultant value, the level of

ink is higher than the effective ink level in the sub-tank. In this embodiment, the "effective ink level in the sub-tank 7" is set higher than the horizontal line that runs through the ink outlet port 48 formed in the sub-tank 7 in Fig. 4.

[0092]

That is, "Ch*" is set equal to or smaller than "the effective amount of ink in the sub-tank 7 - the amount of ink discharged by the recording head 7 for one cleaning operation". When "Ch*" is so set, the sub-tank 7 is set to the full ink state, and even when, before the next ink supply, ink is consumed by printing or flushing and further, the cleaning operation is performed once, the level of the ink in the sub-tank 7 is maintained higher than the horizontal level that runs across the ink outlet port 48 of the sub-tank 7. Thus, when ink is consumed in the above described manner, the ink in the sub-tank 7 is not exhausted nor is it less than the effective ink amount, and a problem that arises when air enters because the ink flow path from the sub-tank 7 to the recording head 6 has been emptied can be avoided.

[0093]

When it is ascertained that the value held by the ink consumption counter 109 does not reach the predetermined value (No), program control returns. When it is ascertained that the value held by the ink consumption counter 109 has reached the predetermined value (Yes), program control advances to the routine for supplying ink to the sub-tank 7.

[0094]

In this embodiment, as is described above, when the level detection result at step S13 is a low ink state and the value held by the ink consumption counter 109 has reached the predetermined value, the supply of ink to the sub-tank 7 is initiated. Since this condition of a logical product is provided, the interval for the supply of ink to the sub-tank 7 can be extended, and the erroneous detection of the amount of ink in the sub-tank 7, which is caused by a factor such as vibration, can be prevented. Thus, the amount of ink retained in the sub-tank 7 can be precisely managed.

[0095]

Specifically, if only the level detection result at step S13 is employed to initiate the supply of ink to the sub-tank 7, the supply of ink is begun in a low ink state. Then, since a full ink state is detected only after a short period of time, the ink supply is halted, and further, after only another short time, the low ink state is detected. Therefore, the supply of ink must be frequently repeated. However, as is described above, since the supply of ink is initiated when a low ink state is detected and it is ascertained that the ink in the sub-tank has been consumed and has reached a predetermined value, the supply of ink is repeated following a satisfactory time interval.

[0096]

Whereas, if only the value held by the ink consumption counter 10 at step S18 is employed to initiate the supply of ink to the sub-tank 7, a little error has to occur in the

calculation performed by the consumed ink quality calculation means 107 in Fig. 7. Therefore, an error is acquired by the repetitive resetting and counting performed by the ink consumption counter 109, and the amount of ink in the sub-tank 7 is gradually increased until it enters the overflow state, or in the worst case, ink leaks from the sub-tank 7. Or, a problem may occur in that by gradually reducing the level of ink the sub-tank 7 is exhausted and air enters the ink flow path that communicates with the recording head 6.

[0097]

As is described above, when a "Yes" decision is obtained at step S18, program control advances to the routine for supplying ink to the sub-tank 7. At step S19, level detection is performed, as ink is supplied to monitor the level of ink in the sub-tank. At this time, in most cases, the level detection result is a low ink state, and at step S20 the supply valve 26 is opened and ink from the main tank 9 is supplied to the sub-tank 7.

[0098]

At step S21, a check is performed to determine whether the period of time at the low level has reached a set time. That is, the time that has elapsed since the supply valve 26 was opened at step S20 is calculated by the timer means 112. At this time, the period of time at the low level has not reached the set time, and a "No" decision is obtained. Therefore, program control returns via the loop (A) in Fig. 8 to step S19, and the ink supply to the sub-tank 7 is monitored.

That is, the ink supply routine from step S19 to step S21 is repeated. When it is ascertained at step S19 that the sub-tank 7 is full, program control is shifted to step S22.

[0099]

At step S22, the supply valve 26 is closed, at step S23, the ink consumption counter 109 for the sub-tank 7 is reset, and at step S24, the latest value held by the ink consumption counter 209 is subtracted from the value held by the cartridge remaining ink counter 110. Program control thereafter returns. For this subtraction, as is described above, the latest ink amount total held by the ink consumption counter 109 for the sub-tank 7 immediately before it is reset is transmitted to the remaining ink counter 110 for the main tank 9, and is subtracted from the ink amount total that indicates the amount of ink remaining in the main tank 9. In this manner, the amount of ink remaining in the main tank 9 can be managed.

[0100]

As is described above, when the overflow state is detected while program control is shifted via the loop (A) and the supply of ink to the sub-tank 7 is monitored, program control enters the previously described routine beginning with step S15. The supply of the compressed air to each main tank 9 is halted, and the supply of ink to each sub-tank 7 is disabled. Then, an error message indicating that maintenance of the recording apparatus is required is displayed on the display means 113.

[0101]

When it is ascertained at step S21 that the period of time at the low level has exceeded the set time, it is assumed that ink has not been satisfactorily supplied even when the predetermined time set for supplying ink to the sub-tank 7 has been reached. Therefore, program control advances to step S25, and the amount of ink remaining in the ink cartridge is examined. In this case, the value held by the remaining ink counter 110 for the main tank 9 is examined. When a low ink state is detected (Yes), it is ascertained that there is a shortage of ink in the ink cartridge, at step S26 the supply valve 26 is closed, and at step S27 the supply halt flag is set. In this case, it is preferable that an error message be displayed on the display means 113 indicating that the ink in the ink cartridge has been exhausted.

[0102]

When it is ascertained at step S25 that the value held by the remaining ink counter 110 for the main tank 9 does not indicate a low ink state (No), it can be assumed that an obstacle has appeared in the ink supply system and that ink can not be supplied to the sub-tank 7. In this case, it is preferable that an error message be displayed on the display means 13 for an ink supply failure.

[0103]

In this embodiment, the ink supply valve has been located along the ink supply path extending from the ink cartridge to the sub-tank, and as the supply valve is opened or closed, the ink has been intermittently supplied to the sub-tank.

However, the present invention need not be applied only for the above described configuration, and an ink transmission pump may be located along the ink supply path leading from the ink cartridge to the sub-tank.

[0104]

Further, in the embodiment, compressed air has been used to exert pressure on the ink cartridge, and upon the application of this pressure, ink from the ink cartridge has been supplied to the sub-tank. However, the present invention can also be applied for a recording apparatus wherein, for example, an ink cartridge is located at a high position in the gravitational direction, so that pressure head difference is used to supply ink to a sub-tank.

[0105]

[Advantages Of The Invention]

As is apparent from this description, according to the ink-jet recording apparatus that employs the method of the invention for supplying ink to the sub-tank, when a low ink state is detected by the ink quantity detection means and when the value held by the consumed ink quantity counter reaches the predetermined ink amount total, ink from the ink cartridge is supplied to the sub-tank. With this arrangement, the repetitive operation by which ink is frequently supplied to the sub-tank can be avoided. Further, the erroneous detection of the quantity of ink in the sub-tank, which is caused by a factor such as vibration, can also be prevented. Thus, it is ensured that the amount of ink in the sub-tank is constantly

controlled within a predetermined range, and that normal printing can continuously be performed.

[Brief Description Of The Drawings]

[Fig. 1]

Fig. 1 is a plan view of the basic arrangement of an ink-jet recording apparatus according to the present invention.

[Fig. 2]

Fig. 2 is a specific diagram showing an ink supply system ranging from an ink cartridge to a recording head.

[Fig. 3]

Fig. 3 is a partially cutaway, perspective view of a sub-tank viewed from one plane direction.

[Fig. 4]

Fig. 4 is a perspective side view of the sub-tank viewed in the same plane direction.

[Fig. 5]

Fig. 5 is a partial cross-sectional view of the state wherein the pressure control valve that is used is a pressure control valve that also serves as a relief valve.

[Fig. 6]

Fig. 6 is a partial cross-sectional view of the air release state obtained by the relief operation.

[Fig. 7]

Fig. 7 is a block diagram showing a control circuit that constitutes a part of the means for supplying ink to the sub-tank that implements the method of the invention.

[Fig. 8]

Fig. 8 is a flowchart showing the control routine for the method of the invention for supplying ink to the sub-tank.

[Fig. 9]

Fig. 9 is a specific diagram showing an example wherein ink quantity detection means erroneously detects the quantity of ink when one magnetoelectric converter is provided.

[Fig. 10]

Fig. 10 is a specific diagram showing an example wherein the ink quantity detection means erroneously detects the quantity of ink when two magnetoelectric converters are provided.

[Description Of The Reference Numerals And Signs]

1: carriage

6: recording head

7 (7a, 7b, 7c, 7d): sub-tank

8: cartridge holder

9 (9a, 9b, 9c, 9d): main tank (ink cartridge)

10: ink supply path (flexible tube)

11: capping means

12: wiping means

15: vacuum pump

21: pneumatic pump

22: pressure control valve

23: pressure detector

24: ink pack

25: pressure chamber

26: ink supply valve

31: float member

32: permanent magnet

33 (33a, 33b): magnetoelectric conversion means (Hall device)

81: valve unit

100: print control means

101: head drive means

102: flushing means

103: cleaning means

104: cleaning instruction detection means

105: pump drive means

107: consumed ink quantity calculation means

108: coefficient setting means

109: ink consumption counter for sub-tank

110: remaining ink counter for main tank

111: write/read means

112: timer means

113: display means

[Designation of Document] Abstract

[Abstract]

[Problem]

It is one objective of the invention to avoid the repetitive operation performed for frequently supplying to a sub-tank, and to prevent erroneous detection of the quantity of ink in a sub-tank due to vibration.

[Means for Resolution]

Ink from an ink cartridge 9 is supplied along an ink supply tube 9 to a sub-tank 7 mounted on a carriage. Provided for the sub-tank 7 are a float member 33 on which a permanent magnet 32 is mounted, and ink quantity detection means is constituted by Hall devices 33a and 33b. Further, a consumed ink quantity counter is also included for calculating the amount of ink ejected or discharged by a recording head 6. When a low ink state is detected by the ink quantity detection means and when the value held by the consumed ink quantity counter has reached a predetermined ink amount total, the supply of ink from the ink cartridge 9 to the sub-tank 7 is initiated.

[Selected Drawing] Fig. 2

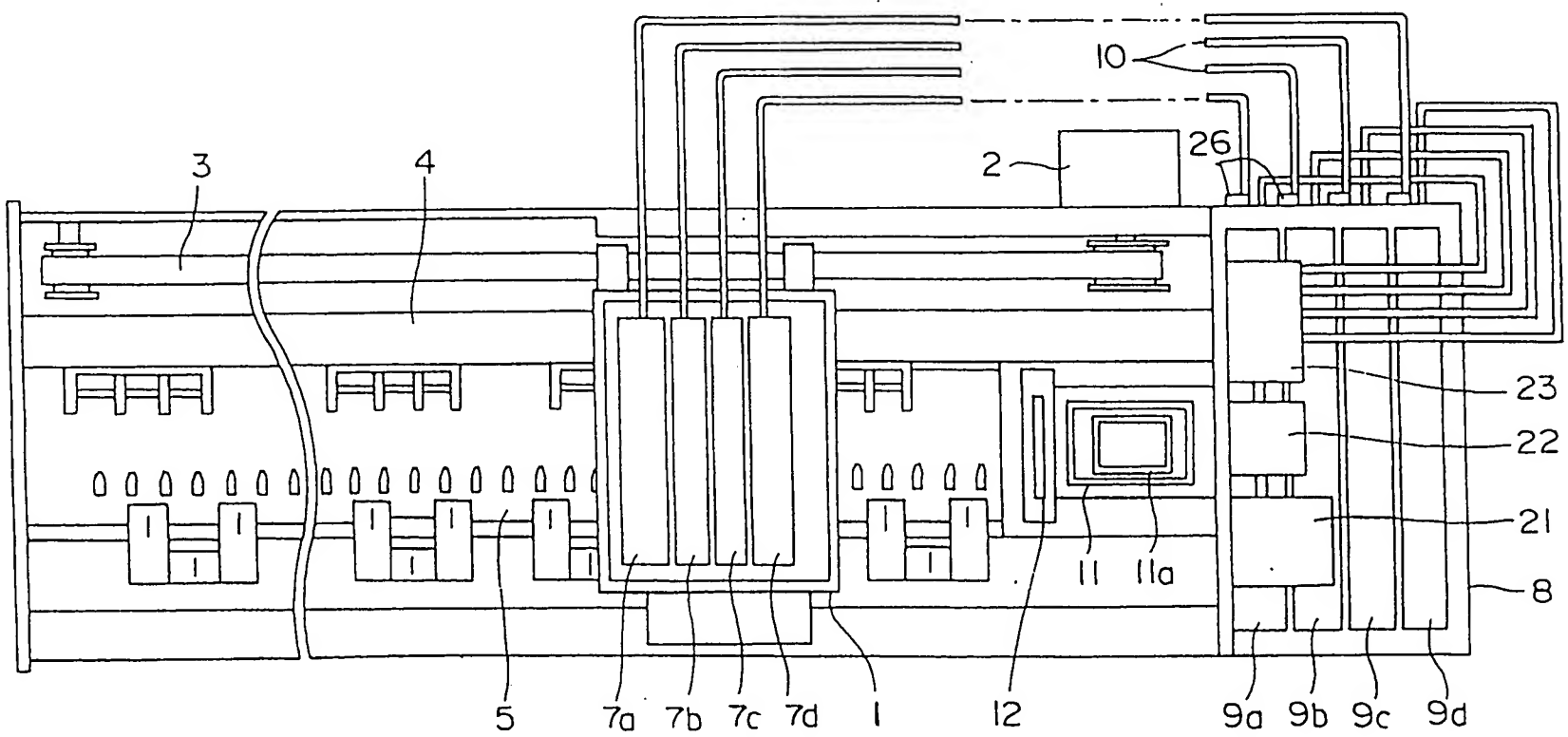


FIG.1

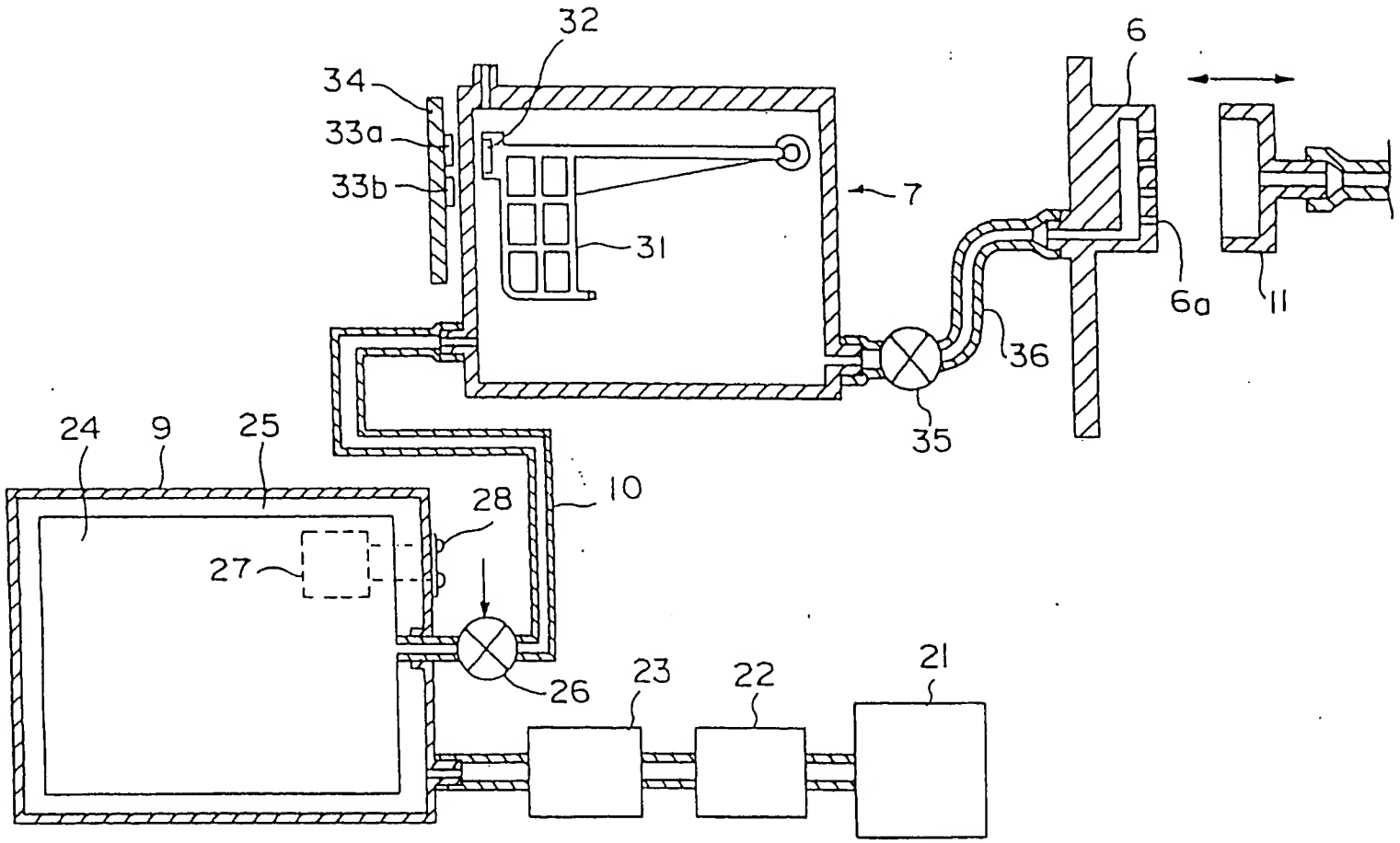


FIG. 2

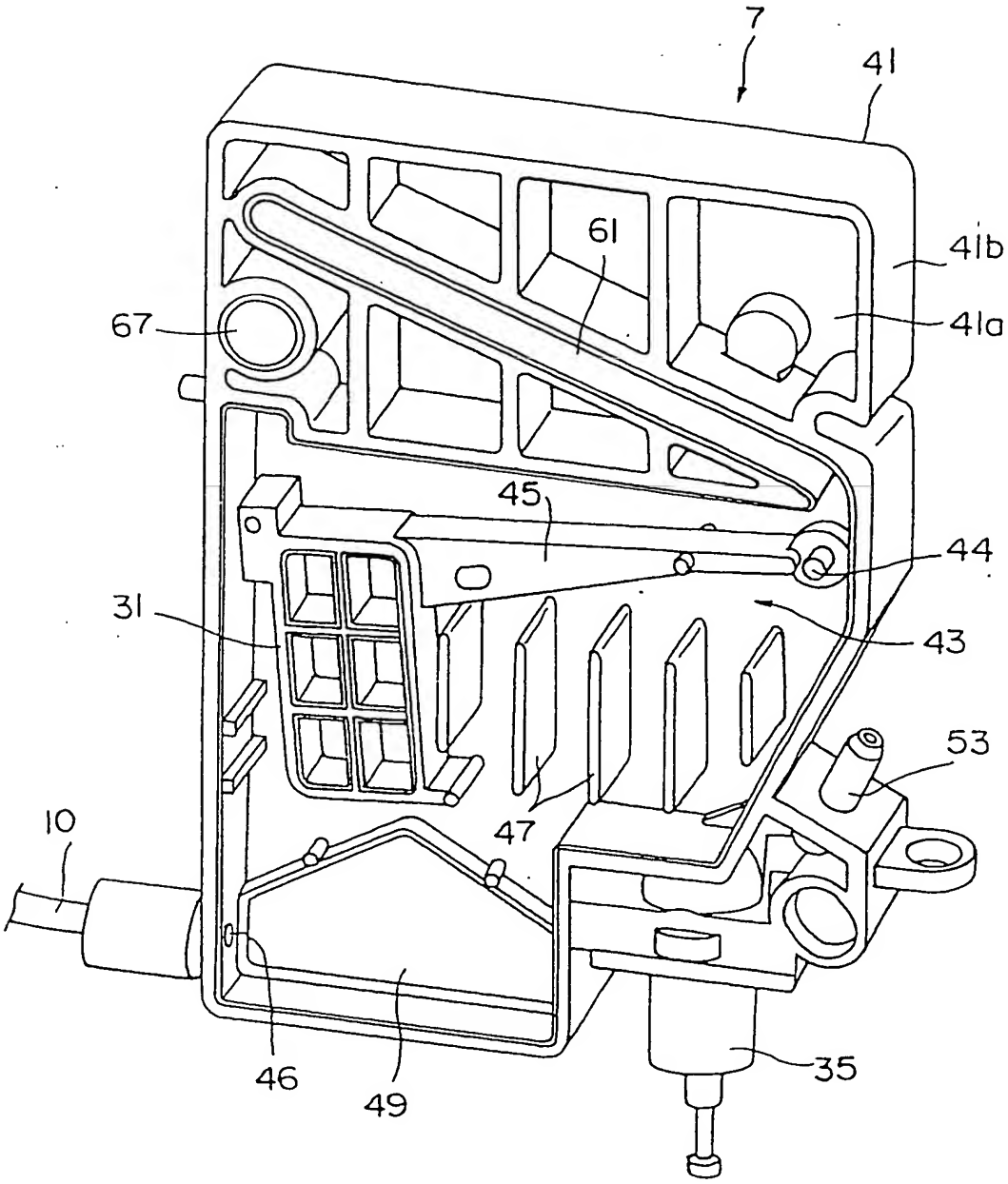


FIG. 3

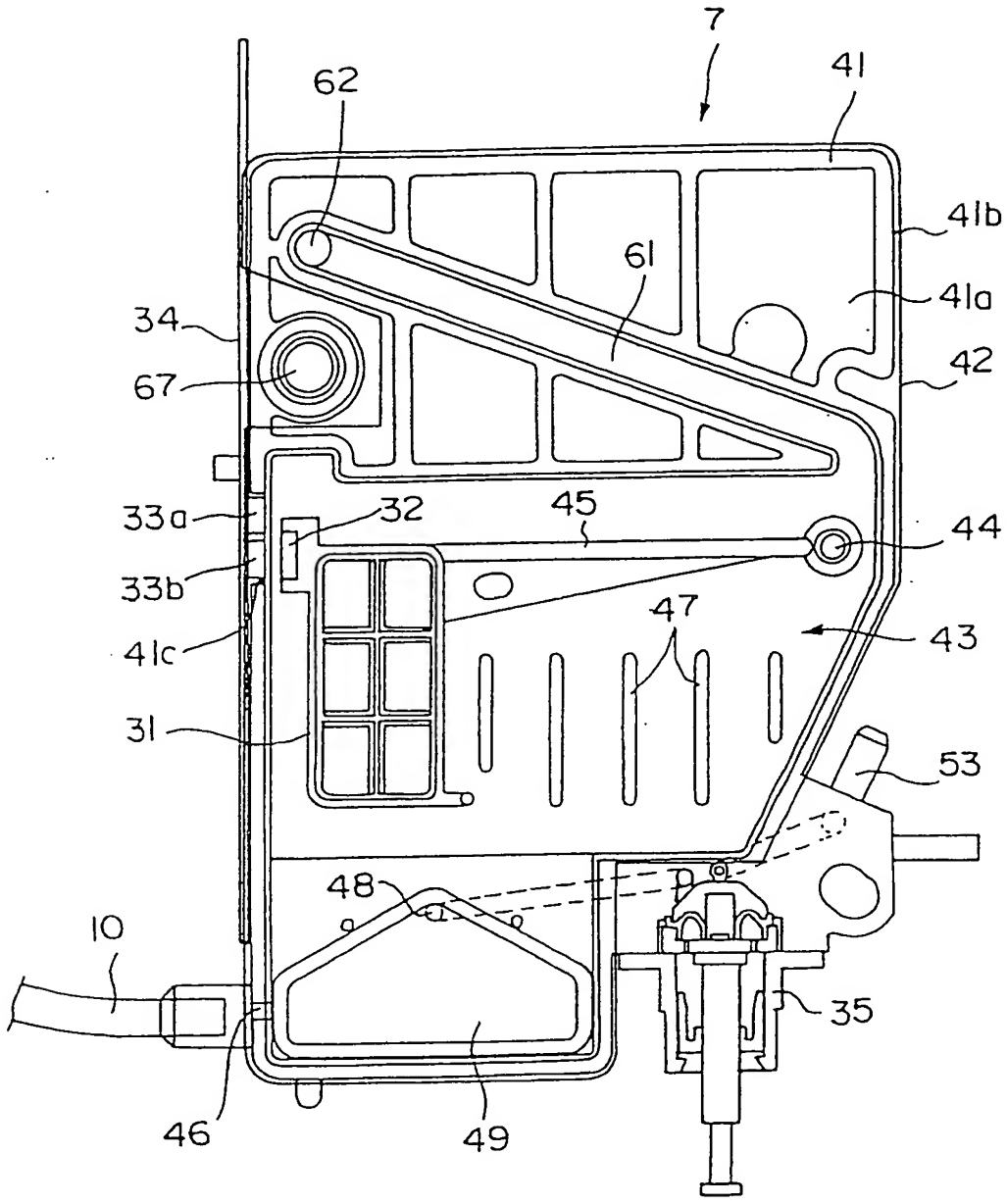

7
62
41
41b
61
41a
34
42
67
33a
32
45
44
33b
47
43
41c
31
53
48
10
35
46
49

FIG. 4

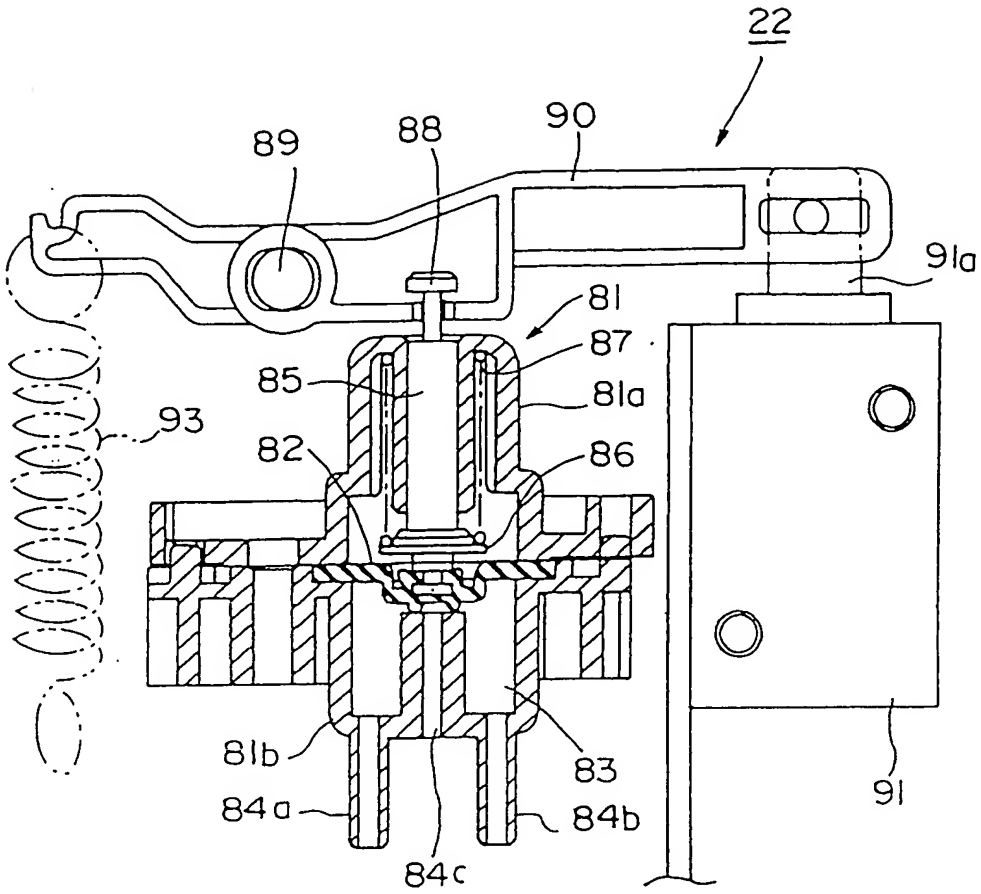


FIG. 5

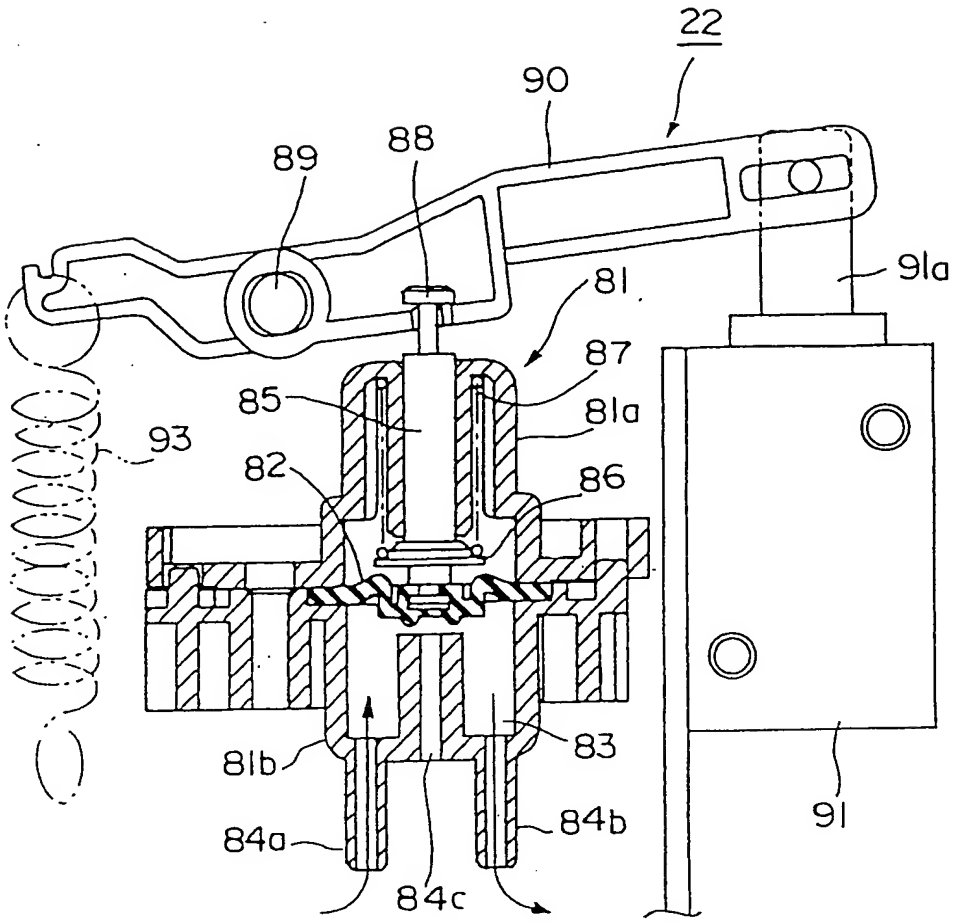
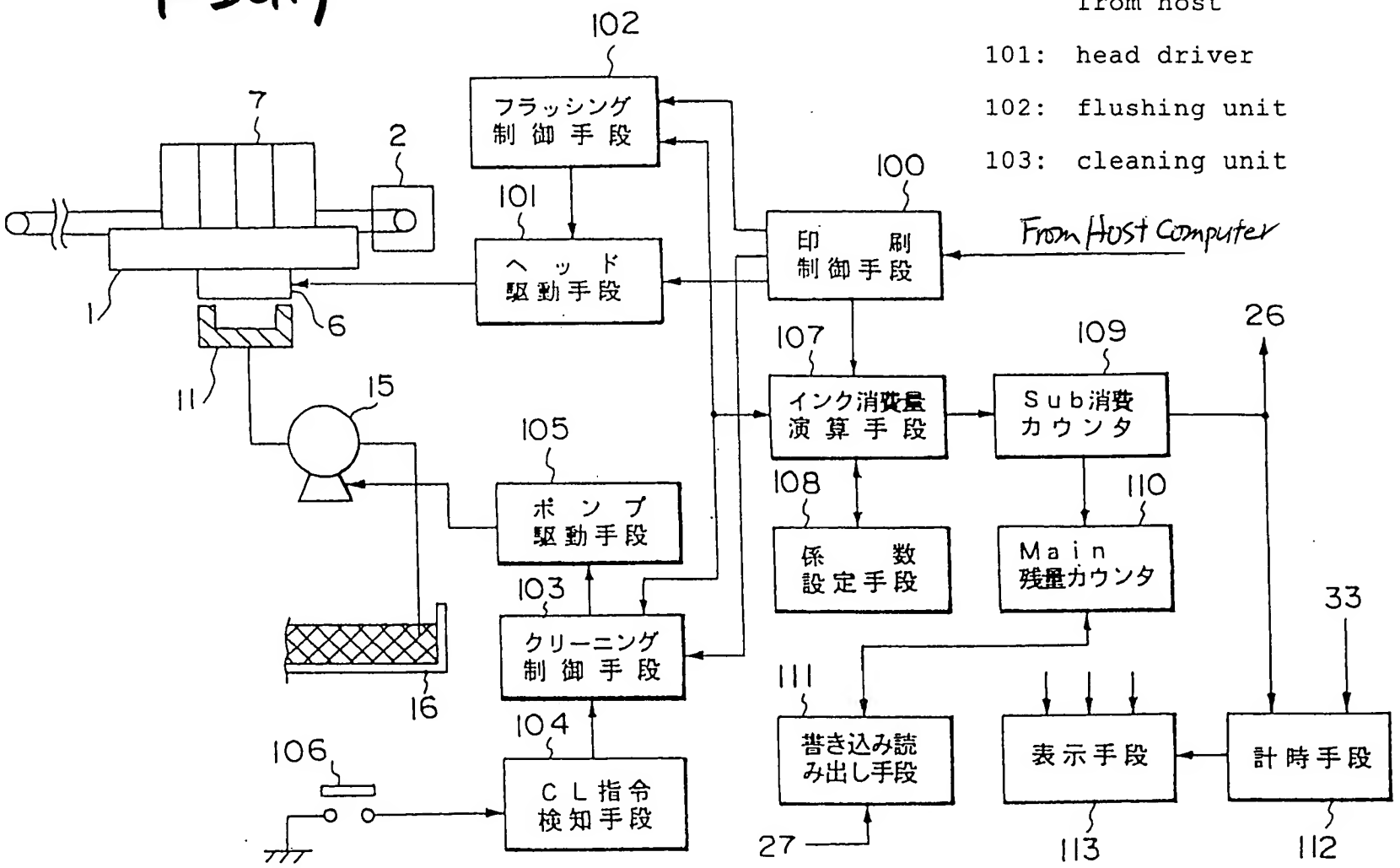


FIG.6

FIG.7



100: print controller from host

101: head driver

102: flushing unit

103: cleaning unit

104: CL instruction detector

105: pump driver

107: an ink consumption calculator

108: coefficient setting unit

109: Sub-tank ink consumption counter

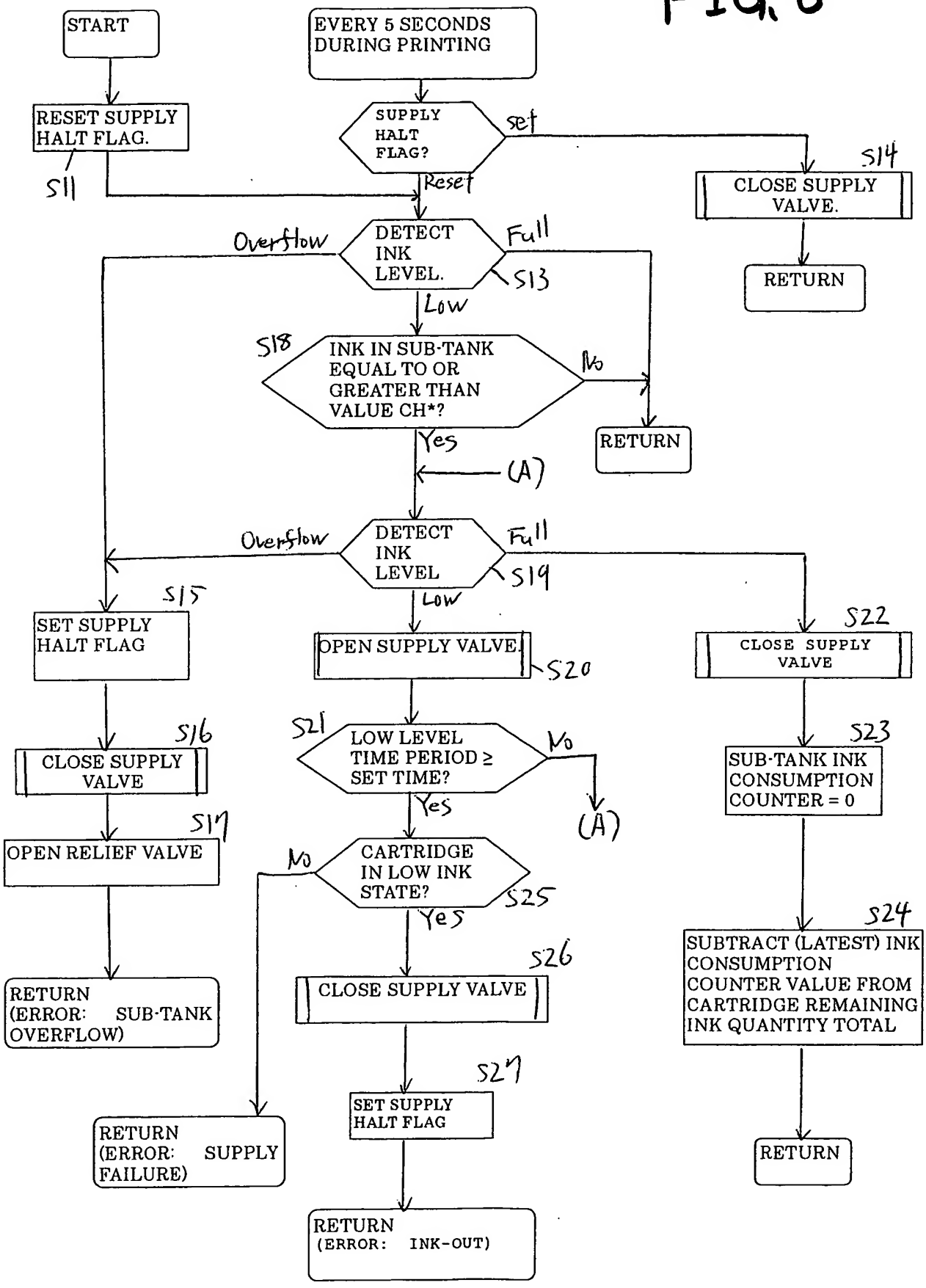
110: Main tank remaining ink counter

111: write/read unit

112: timer unit

113: display unit

FIG. 8


START
RESET SUPPLY HALT FLAG.
S11
EVERY 5 SECONDS DURING PRINTING
SUPPLY HALT FLAG?
set
Reset
S14
CLOSE SUPPLY VALVE.
RETURN
DETECT INK LEVEL.
Overflow
Full
S13
Low
S18
INK IN SUB-TANK EQUAL TO OR GREATER THAN VALUE CH*?
No
Yes
RETURN
(A)
DETECT INK LEVEL
Overflow
Full
S19
Low
S15
SET SUPPLY HALT FLAG
OPEN SUPPLY VALVE
S20
S22
CLOSE SUPPLY VALVE
S16
CLOSE SUPPLY VALVE
S21
LOW LEVEL TIME PERIOD ≥ SET TIME?
No
Yes
(A)
S23
SUB-TANK INK CONSUMPTION COUNTER = 0
S17
OPEN RELIEF VALVE
No
CARTRIDGE IN LOW INK STATE?
S25
Yes
S26
CLOSE SUPPLY VALVE
S24
SUBTRACT (LATEST) INK CONSUMPTION COUNTER VALUE FROM CARTRIDGE REMAINING INK QUANTITY TOTAL
RETURN (ERROR: SUB-TANK OVERFLOW)
S27
SET SUPPLY HALT FLAG
RETURN (ERROR: SUPPLY FAILURE)
RETURN
RETURN (ERROR: INK-OUT)

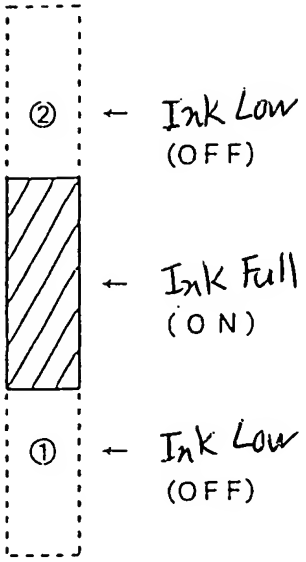


FIG.9

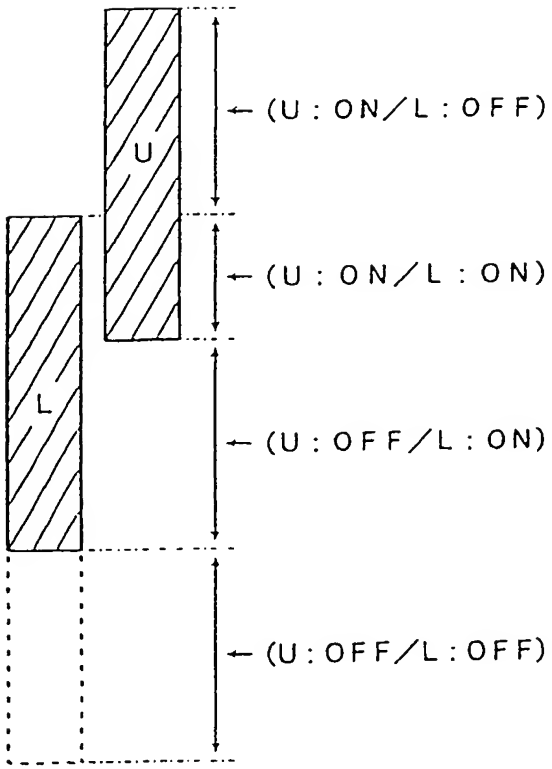


FIG.10A

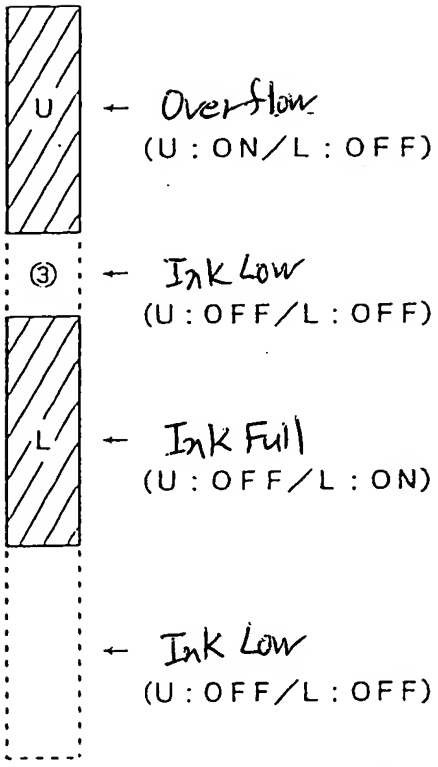


FIG.10B